

CENTRAL VALLEY FLOOD MANAGEMENT PLANNING PROGRAM



2012 Central Valley Flood Protection Plan

Levee Performance Scope Definition Work Group Summary Report

November 2009

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This Document Prepared by:

Management Review

Gary Hester
DWR
CVFMP Program Manager

Ken Kirby
Kirby Consulting
FloodSAFE Executive
Sponsor

DWR Team

Mike Inamine
DWR
Lead

Roger Lee
DWR
CVFPO

Joseph Bartlett
DWR
CVFPO

Technical Support

Yung-Hsin Sun
MWH
Consultant Team, Principal-
in-Charge

Mary Jimenez
MWH
Technical Lead
Senior Engineer

Josh Yang
MWH
Associate Engineer

Dorian Fougeres
Center for Collaborative
Policy
Lead Facilitator

Nicole Ugarte
Center for Collaborative
Policy
Facilitation Support

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1.0 Introduction

Recent legislation directs the California Department of Water Resources (DWR) to prepare a Central Valley Flood Protection Plan (CVFPP) and submit it to the Central Valley Flood Protection Board (Board) by January 1, 2012. The CVFPP will document and assess current performance of the State-Federal flood protection system in the Sacramento and San Joaquin valleys and make recommendations to improve integrated flood management¹ for much of the Sacramento and San Joaquin valleys (Figure 1-1). The CVFPP is subject to revisions every five year thereafter. The 2012 CVFPP will:

- Promote understanding related to integrated flood management from State, Federal, local, regional, tribal and other perspectives (e.g., agriculture, urban, rural, environment, environmental justice (EJ), etc.)
- Create a broadly supported vision for improving integrated flood management in Central Valley
- Develop new data and information that can be shared for many purposes

The Levee Performance Scope Definition Work Group (LPSDWG) was formed to provide input to DWR in the scope of levee performance that will be addressed in the 2012 CVFPP.

¹ Integrated Flood Management is an approach to dealing with flood risk that recognizes the interconnection of flood management actions within broader water resources management and land use planning; the value of coordinating across geographic and agency boundaries; the need to evaluate opportunities and potential impacts from a system perspective; and the importance of environmental stewardship and sustainability (DWR, Draft FloodSAFE Strategic Plan, 2008).

2012 Central Valley Flood Protection Plan
Levee Performance Scope Definition Work Group Summary Report

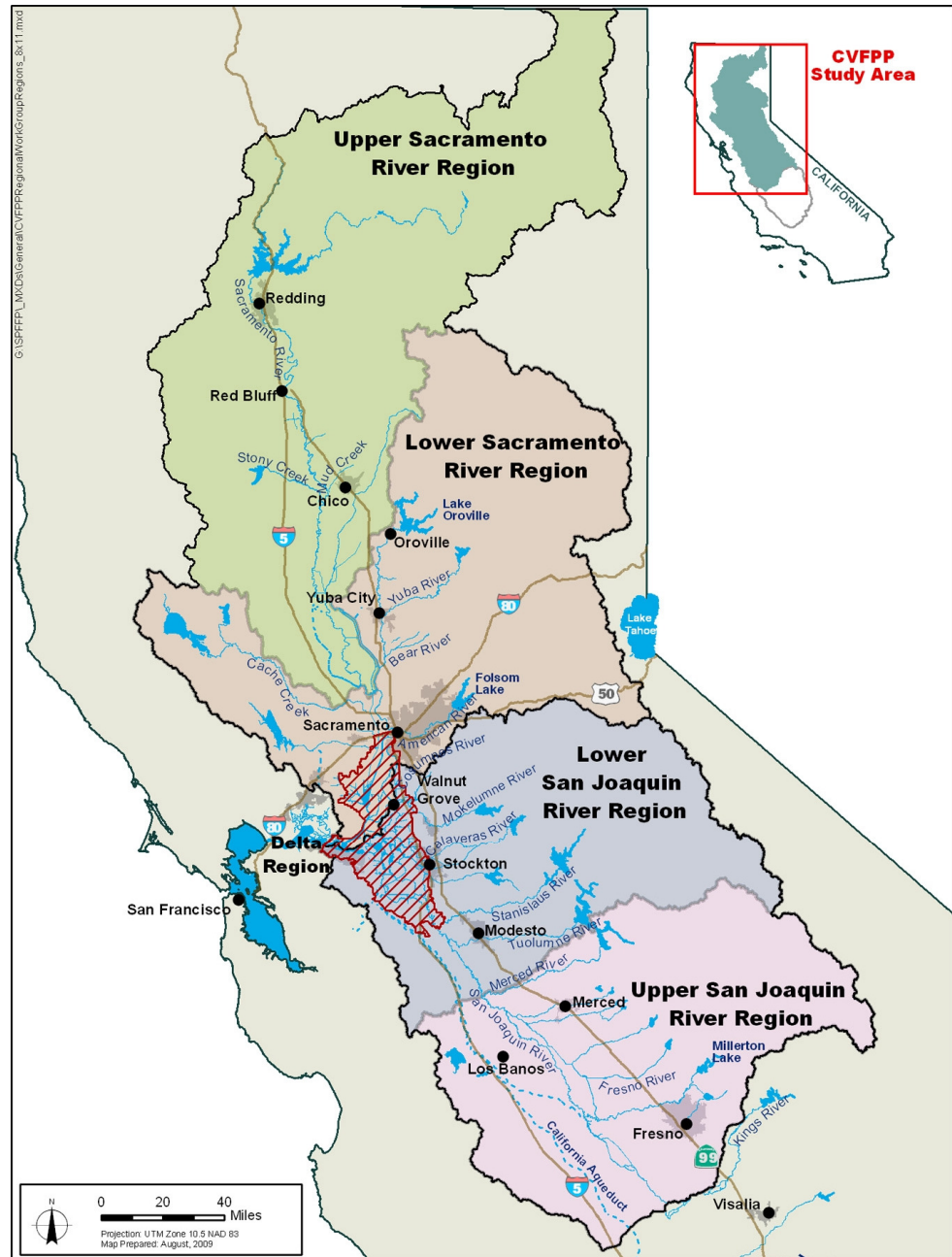


Figure 1-1. CVFPP Study Area

1.1 Work Group Roles and Responsibilities

The LPSDWG consists of the DWR representatives, voluntary members, and supporting staff.

1.1.1 DWR Representatives

The work group includes the following DWR representatives:

1. Ken Kirby, Central Valley Flood Management Program
2. Mike Inamine, Division of Flood Management
3. Roger Lee, Central Valley Flood Protection Office
4. Joseph Bartlett, Central Valley Flood Protection Office

1.1.2 Volunteer Members

The work group includes the following members from a broad range of interests and perspectives:

1. Chris Neudeck, Reclamation District (RD) 17 and Twitchell Island
2. Gil Labrie, Brannan-Andrus Levee Maintenance District
3. Jeff Twitchell, Levee District #1 of Sutter County
4. Les Harder, SAFCA and Three Rivers Levee Improvement Authority (TRLIA)
5. Mary Perlea, U.S. Army Corps of Engineers (USACE)
6. Peter Buck, SAFCA
7. Reggie Hill, Lower San Joaquin Levee District
8. Ron Heinzen, San Joaquin Area Flood Control Agency (SJAFCA)
9. Stuart Edell, Butte County Public Works

1.1.3 Supporting Staff

The work group includes the following supporting staff:

1. Mary Jimenez, MWH
2. Josh Yang, MWH
3. Steve Chainey, EDAW/AECOM
4. Dorian Fougères, Center for Collaborative Policy
5. Nicole Ugarte, Center for Collaborative Policy

1.2 Work Group Purpose and Scope

The purpose of the LPSDWG was to provide input on the following questions:

1. What are the key factors that would affect levee performance to be covered in the 2012 plan?
2. What are the primary categories of existing problems and expected future challenges related to levee performance within the study area?
3. What are the most important documents available to use as reference material related to levee performance problems, opportunities, and standards (considering what has already been provided to DWR's levee evaluation programs)?
4. What levee performance evaluation activities should the 2012 Plan consider (in addition to what is being considered under DWR's levee evaluation programs)?

1.3 Work Group Deliverables

The charge of the LPSDWG is to produce the deliverables listed below. The resulting written material will inform all relevant work to develop content for the CVFPP. The first direct application of the products of the LPSDWG will be in the 5 regional conditions work groups. Specific, physical objectives related to levee performance will be developed in the regional conditions work groups, along with all of the other objectives for that region. LPSDWG deliverables include the following:

1. **List of Key Factors that May Affect Levee Performance:**
Review and update the list of key factors that affect levee performance and should be covered in the 2012 Central Valley Flood Protection Plan to create a successful plan. Prioritize the list into 3 levels of importance (critical, important, less important).
2. **List of Existing Problems and Expected Future Challenges within the CVFPP Project Area Related to Levee Performance:**
Review and update the list of existing problems and expected future challenges related to levee performance within the planning area. Additional details about the identified problems and future challenges will be developed and captured in the regional conditions work groups.

3. **List of Reference Material Related to Levee Performance Problems, Opportunities, and Standards:** Considering material provided previously to DWR for the levee evaluations programs, create a list of most applicable documents to use as reference material related to levee performance problems, opportunities, and standards during development of the CVFPP.
4. **List of Relevant Levee Performance Evaluation Activities:** Review and update a list of previously compiled levee performance evaluation activities to develop a comprehensive list of other levee performance evaluation activities that the CVFPP Plan Development Team should become familiar with and coordinate with regularly.

1.4 Purpose of this Report

This LPSDWG Summary Report records the outcome of the group and presents the deliverables identified above in Section 1.3. It serves as the vehicle for providing LPSDWG input to the development of the Regional Conditions Report (RCR), which comprises the first four chapters of the CVFPP. This input from the LPSDWG will not have its own section in the RCR, rather it will be combined with input from other topic and regional conditions work groups to inform the whole report. Levee performance concepts will be incorporated in all aspects of the planning process, and thus will be integrated throughout the final RCR and CVFPP.

LPSDWG members will be offered the opportunity to provide input on the draft version of the RCR. This will serve as a check to ensure that members are comfortable with the incorporation of their input and present a chance to provide additional comments.

This LPSDWG Summary Report will remain a draft document until the CVFPP is finalized, as will all interim CVFPP documents. Further development of the CVFPP may yield additional improvement to the results documented in this report.

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2.0 Key Factors that May Affect Levee Performance to be Covered in the 2012 Plan

To document factors that may affect levee performance within the planning area for Deliverable #1, the LPSDWG partners listed 25 factors, including 21 that applied to the entire planning area plus 4 region-specific factors listed in Table 2-1. Three levee failure mechanisms (internal erosion, external erosion, and slope stability) were considered to generate and prioritize factors as critical, important, or less important. An outline is presented in Section 2.2 that documents the work group's discussion process used to develop and prioritize key factors based on levee failure mechanisms.

2.1 Factors and Recommended Prioritization

Table 2-1 lists 25 key factors that may affect levee performance and the prioritization recommended by the partners (critical (C), important (I), or less important (LI)).

Table 2-1. List of Key Factors and Recommended Prioritization by Levee Failure Mechanism

Factors	Internal Erosion ¹	External Erosion ¹	Slope Stability ¹
Levee Foundation	C	C	C
Levee Geometry	C	C	C
Encroachments	I	LI	I
Lack of Vegetation Cover	LI	C	I
Vegetation Roots and Treefall	LI	LI	LI
Land Use Practices Outside Right of Way	I	LI	I
Burrowing Rodents	C	LI	LI
Hydrology and Hydraulics (Hydraulic Head)	C	C	C
Impediments to Flood Fighting	I	I	I
Structures Outside Levee Right of Way	C	LI	LI
Construction and Manmade Activities	I	LI	LI
Unremediated Past Seepage Distress	C	LI	LI
Levee Soil Material	C	C	C
Waterside Erosion	C	C	C
Penetrations Through or Under Levee	C	LI	LI
Closure Structures and Embankments	LI	LI	LI
Earthquakes (Study Area, Excluding Delta)	LI	LI	LI
Delta-Specific	C	LI	C
Delta Island Subsidence: Organic Soil Decomposition ¹	LI	LI	LI
Levee Settlement (Study Area, Excluding Delta and Upper San Joaquin)	LI	LI	LI
Delta-Specific Consolidation of Organic Foundation Materials ²	LI	I	LI
Upper San Joaquin-Specific Groundwater and Oil Extraction	I	I	LI
Substandard Levee Modifications (Study Area, Excluding Delta)	I	LI	I
Delta-Specific	I	LI	C
Rainfall Duration and Intensity	LI	I	I

Note:

1. The 'Less Important' category is used to denote factors that are less essential or less prevalent throughout the planning area (or region noted), not factors that do not occur.
2. The soft organic soils in the delta levee foundations that are responsible for major settlement also has complex low shear strengths that are associated with slope stability problems.

Key:

C = critical (red shading)

I = important (orange shading)

LI = less important (yellow shading)

2.2 Outline of Failure Mechanisms for Key Factor Prioritization

The outline below documents the LPSDWG's discussion process used to develop and prioritize key factors based on levee failure mechanisms for Deliverable #1.

Internal Erosion

1. Under Seepage
 - a. Levee Foundation
 - i. Historical Channel Fill And Mining Deposits
 - ii. Past Levee Breaches and Sand Boils
 - iii. Levee Modifications
 - iv. Pre-Existing Geomorphology
 - v. General geotechnical stratigraphy
 - b. Levee Geometry
 - c. Waterside Erosion
 - d. Encroachments
 - i. Swimming Pools
 - ii. Ditches
 - e. Vegetation Roots and Treefall*
 - i. Treefall
 - ii. Root Penetration/Piping
 - f. Land Use Practices
 - i. Excavations Outside Right of Way
 - ii. Agriculture
 - iii. Burrowing Rodent Habitat

- iv. Visual and Physical Obstructions For Flood Fighting, Inspection, and Maintenance
- g. Penetrations
 - i. Pipes
 - ii. Utilities
 - iii. Foundations
 - iv. Power Poles
 - v. Wells (water wells, gas wells)
- h. Burrowing Rodents
- i. Hydraulic Head: Peak And Duration
 - i. Climate Change
 - ii. Reservoir Operations
 - iii. Flood Relief Structures
 - iv. Upstream/Downstream Levee Failures
 - v. Different Levels Of Protection
 - vi. Maintaining Channel Capacities
- j. Impediments to Flood Fighting, Inspection, and Maintenance
- k. Structures Outside Levee Right of Way
- l. Construction and Other Manmade Activities
 - i. Hydraulic Fracturing
 - ii. Vibrations
 - iii. Excavations
 - iv. Dredging
- m. Unremediated Past Seepage Distress

2. Through Seepage

- a. Levee Soil Material
- b. Waterside Erosion
- c. Land Use Practices
 - i. Visual and Physical Obstructions for Flood Fighting, Inspection, and Maintenance
 - ii. Burrowing Rodent Habitat
- d. Levee Geometry
- e. Encroachments
 - i. Gardens
 - ii. Irrigations
 - iii. Posts
 - iv. Fences
 - v. Gates
 - vi. Residential Structures
 - vii. Retaining Walls and Pump Stations
 - viii. Swimming pools in levee slopes
- f. Vegetation Roots*
- g. Penetrations
 - i. Pipes
 - ii. Power poles
- h. Closure Structures
 - iii. Railroad/Highway Crossing
- i. Burrowing Rodents

- j. Hydraulic Head: Peak and Duration
 - i. All included for Internal Erosion, Item 1i.
- k. Impediments to Flood Fighting, Inspection, and Maintenance
- l. Construction and Other Manmade Activities
 - i. Hydraulic Fracturing
 - ii. Vibrations
 - iii. Levee Excavations
- m. Unremediated Past Seepage Distress
- 3. Earthquakes
 - a. Liquefaction
 - b. Cracking
 - c. Differential Movement
 - d. Differential Settlement
- 4. Non-Earthquake Differential Settlement
 - a. Organic Soil Decomposition (Delta)
 - b. Subsidence: Levee Settlement (Delta) and Groundwater and Oil Extraction (Upper San Joaquin)
 - c. Construction

External Erosion

- 1. Overtopping
 - a. Geometry
 - b. Levee Soil Material and Vegetation Cover
- 2. Wave Wash
 - a. Geometry

- b. Levee Soil Material and Vegetation Cover
- 3. Fluvial/Bank Erosion
 - a. Geomorphology
- 4. Rainfall Duration and Intensity
- 5. Vegetation Cover, Roots, and Treefall*
 - a. Erosion
 - i. Reduce Scour Velocity
 - ii. Wave Attenuation
 - iii. Soil Reinforcement
 - iv. Treefall
 - v. Local Hydraulic Scour
 - vi. Channel Meandering

Slope Stability (Earthquakes, Rapid Drawdown, Seepage)

- 1. All Factors For Under Seepage
- 2. All Factors For Through Seepage
- 3. All Factors For External Erosion
- 4. Construction and Other Manmade Activities
 - a. Roads/Highways
 - b. All included under Internal Erosion, Item 21.

Please note the following:

- Where topics are repeated they are meant to include all the factors listed in the first explanation. In some cases additional factors were added to subsequent explanations.
- The asterisk (*) indicates that there was disagreement among the LPSDWG partners on its effect, and that more discussion would be needed to determine how vegetation related to the other factors.

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3.0 Primary Categories of Existing Problems and Expected Future Challenges Within the CVFPP Planning Area Related to Levee Performance

For Deliverable #2, existing problems and expected future challenges related to the key factors developed for Deliverable #1 were discussed with respect to three categories:

1. Technical Risk Factor
2. Policy
3. Financial Constraints

The LPSDWG partners agreed that the existing problems were not significantly different from the expected future challenges, and thus to combine the two lists for one discussion.

The key factors recommended in Table 2-1 were listed according to overall priority in Table 3-1 using the following criteria:

- A key factor was determined to be *Critical* if the factor was categorized as critical for two or more of the three main failure mechanisms (Internal Erosion, External Erosion, and Slope Stability), or critical for one failure mechanism and important for another.
- A key factor was determined to be *Less Important* if the factor was categorized as less important for two or more failure mechanisms.
- All remaining key factors were categorized as *Important*.

Table 3-1. Existing Problems and Expected Future Challenges by Category

Problems and Challenges Related to Critical Key Factors	
Levee Foundation	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Under seepage • Slope stability • Seismic
2. Policy	<ul style="list-style-type: none"> • Variable design flood elevation • Variable safety factors • Engineering standards change over time • New regulations • New government priorities • New legislation
3. Financial Constraints	<ul style="list-style-type: none"> • USACE benefit/cost ratio • Limited Federal/State/local funding
Levee Geometry	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Inability to access for flood fighting • Slope stability • Internal erosion to through seepage • Erosion below and above levee toe • Hydraulic constraints to waterside improvements
2. Policy	<ul style="list-style-type: none"> • Insufficient, inconsistent minimum State or Federal standards for existing and new levees • Regulatory constraints to waterside improvements and repairs
3. Financial Constraints	<ul style="list-style-type: none"> • High cost to bring existing levees to new standards
Hydrology and Hydraulics	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Overtopping • Landside erosion by overtopping • Climate change affecting watershed hydrology and hydraulics • Upstream/downstream levee failures • Development in the watershed that increases peak runoff • Development in the bypasses and overflow that decreases flow conveyance • Structural weakening due extended time of high stage and rapid drawdown
2. Policy	<ul style="list-style-type: none"> • Reservoir operations • Flood relief structures • Different levels of protection • Maintaining channel capacities • Operation of closure structures • Inconsistent freeboard standards among Federal and State agencies • Unresolved risk, uncertainty and confidence level criteria
3. Financial Constraints	<ul style="list-style-type: none"> • USACE benefit/cost ratio • Limited Federal/State/local funding

3.0 Primary Categories of Existing Problems and Expected Future Challenges Within the CVFPP Planning Area Related to Levee Performance

Table 3-1. Existing Problems and Expected Future Challenges by Category (Contd.)

Problems and Challenges Related to Critical Key Factors, Contd.	
Levee Soil Material	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Availability of borrow material • Through seepage • Stability • Material quality and soil contamination • Tension cracks • Embankment erosion
2. Policy	<ul style="list-style-type: none"> • Environmental restrictions on use of dredge materials and work periods • Environmental and cultural restrictions on use of borrow material • Variable acceptance criteria by different agencies • Surface Mining and Reclamation Act regulations and constraints • Air quality restrictions on use of aged equipment
3. Financial Constraints	<ul style="list-style-type: none"> • Cost of material sources and transportation • Cost of material placement • Cost of permitting
Waterside Erosion	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Levee slope failure • Seepage through the levee and foundation • Loss of waterside berm • Loss of critical sections • Impact of geomorphology • Source of sediment deposition downstream • River meander • Weak composition of levee and foundation • Loss of vegetation and natural habitat
2. Policy	<ul style="list-style-type: none"> • Environmental constraints • USACE policy on vegetation
3. Financial Constraints	<ul style="list-style-type: none"> • Cost of bank protection • Cost of mitigation • Limited locations available for bank habitat mitigation • Limited Federal and State funding
Earthquake (in Delta)	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Slope stability • Settlement due to liquefaction • Increased salinity of water supply • Interruption of water deliveries south of the Delta • Loss of islands • Wave erosion of flooded islands • Loss of lives • Sea level rise • Loss or interruption of transportation and infrastructure
2. Policy	<ul style="list-style-type: none"> • Inconsistency in analytical methods and lack of regulation thereof • Low benefit/construction cost ratio • Whether to protect all Delta islands (DRMS)
3. Financial Constraints	<ul style="list-style-type: none"> • High cost of seismic mitigation and reclaiming flooded islands • Low benefit/construction cost ratio

Table 3-1. Existing Problems and Expected Future Challenges by Category (Contd.)

Problems and Challenges Related to Critical Key Factors, Contd.	
Substandard Levee Modifications and Repairs (in Delta)	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Slope stability • Seepage through the levee • Seepage through the foundation • Settlement • Wave and wake erosion • Loss of critical section
2. Policy	<ul style="list-style-type: none"> • Lack of oversight • Time required for environmental permitting
3. Financial Constraints	<ul style="list-style-type: none"> • Inadequate resources of local levee maintaining agencies • Liability for regulatory penalties • Cost of environmental mitigation • Loss of Federal funding for flood repair • Liability for inadequate modifications and repairs resulting in failure
Problems and Challenges Related to Important Key Factors	
Encroachments	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Inability to access for flood fighting, maintenance, repairs, and inspection • Slope stability • Internal erosion to through seepage • Hydraulic constraints to waterside improvements • Lack of information regarding existing structures • Waterside encroachments that exacerbate the erosion of the slope • Inability to remediate past seepage distress
2. Policy	<ul style="list-style-type: none"> • Insufficient, inconsistent minimum State or Federal standards for existing and new levees • Regulatory constraints to waterside improvements and repairs • Difficulty of policy enforcement • Constraints of private property, history, and local jurisdiction
3. Financial Constraints	<ul style="list-style-type: none"> • High cost to bring existing levees to new standards • High cost to analyze encroachments • High cost and duration of litigation

3.0 Primary Categories of Existing Problems and Expected Future Challenges Within the CVFPP Planning Area Related to Levee Performance

Table 3-1. Existing Problems and Expected Future Challenges by Category (Contd.)

Problems and Challenges Related to Important Key Factors, Contd.	
Impediments to Flood Fighting	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Lack of access for inspection, flood fighting, and maintenance • Availability of materials • Availability of personnel • Safety of personnel and equipment
2. Policy	<ul style="list-style-type: none"> • Hazardous materials constraints • Environmental and cultural restrictions on use of borrow material • Timely resource agency consultation process • Criteria for emergency relief breaches • Surface Mining and Reclamation Act regulations and constraints • Confused command structure before Incident Command System is triggered • Government endorsement of a levee breach or flood diversion • Lack of specificity in local emergency response plans and communication • Lack of evacuation plans • Inconsistent policy for government involvement in non-project levees
3. Financial Constraints	<ul style="list-style-type: none"> • Availability of government resources • High cost of materials and transportation • High cost of post-project mitigation • High cost of pumping • High cost of loss of land use
Lack of Vegetation Cover	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Loss of waterside berm and critical sections due to erosion • Impact of geomorphology • Source of sediment deposition downstream • River meander • Loss of natural habitat due to erosion • Progressive slope failure due to erosion of the bottom of the slope • Soil conditions not conducive to vegetation • Grazing practices
2. Policy	<ul style="list-style-type: none"> • USACE policy on vegetation • Environmental constraints • Variable acceptance criteria by different agencies
3. Financial Constraints	<ul style="list-style-type: none"> • Cost of bank protection • Cost of mitigation • Limited locations available for bank habitat mitigation

Table 3-1. Existing Problems and Expected Future Challenges by Category (Contd.)

Problems and Challenges Related to Important Key Factors, Contd.	
Land Use Practices Outside Right of Way	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Rodent food supply • Excavations, including irrigation and drainage ditches • Lack of access for flood fighting, maintenance, repair, and inspection • Waterworks, irrigation, and groundwater recharge • Adjoining infrastructure • Urbanization and development outside of the levee right of way • Limitation of under seepage mitigation alternatives and levee setbacks
2. Policy	<ul style="list-style-type: none"> • Lack of complete policy for control for areas outside levees • Lack of permitting authority and policy outside the right of way • Inconsistent and emerging right of way width standards
3. Financial Constraints	<ul style="list-style-type: none"> • Cost and duration of condemnation • Cost of mitigating landside practices • High cost of real estate acquisition
Burrowing Rodents	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Through seepage • Under seepage • Slope stability • Potential impacts on flood fighting • Difficulty identifying seepage paths • Progressive slope failures • Lack of understanding of how vegetation affects rodent populations and activity
2. Policy	<ul style="list-style-type: none"> • Environmental constraints • Inconsistent grouting policies • Inability to control rodent food sources and habitat within and beyond levee right of way, including channels and floodways • Conflicting environmental constraints, such as habitat restoration, and levee safety practices
3. Financial Constraints	<ul style="list-style-type: none"> • Increased cost for rodent control • Increased cost for mitigation

3.0 Primary Categories of Existing Problems and Expected Future Challenges Within the CVFPP Planning Area Related to Levee Performance

Table 3-1. Existing Problems and Expected Future Challenges by Category (Contd.)

Problems and Challenges Related to Important Key Factors, Contd.	
Structures Outside Levee Right of Way	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Excavations, including irrigation and drainage ditches • Lack of access for flood fighting, maintenance, repair, and inspection • Waterworks, irrigation, and groundwater recharge • Adjoining infrastructure • Urbanization and development outside of the levee right of way • Limitation of underseepage mitigation alternatives and levee setbacks • Lack of technical information regarding existing structures • Impact of owner modification of existing structures • Lack of owner maintenance of existing structures
2. Policy	<ul style="list-style-type: none"> • Lack of complete policy for control for areas outside levees • Lack of permitting authority and policy outside the right of way • Inconsistent and emerging right of way width standards
3. Financial Constraints	<ul style="list-style-type: none"> • Cost and duration of condemnation • Cost of mitigating outside structures • High cost of real estate acquisition • High cost of investigating structures
Unremediated Past Seepage Distress	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Inconsistent or lack of information (for example, location, geotechnical information) • Challenge of analyzing progressive degradation of levee and foundation • Poor records • Inconsistent assessment, reporting and repair • Improper repair
2. Policy	<ul style="list-style-type: none"> • Lack of standard reporting policy • Lack of standard repair policy • Lack of policy to prevent temporary repairs from becoming permanent repairs
3. Financial Constraints	<ul style="list-style-type: none"> • Cost of remediation • Cost of reporting • Cost of removal of past temporary repairs and replacement with permanent repairs • Potential cost of right of way for permanent repairs

Table 3-1. Existing Problems and Expected Future Challenges by Category (Contd.)

Problems and Challenges Related to Important Key Factors, Contd.	
Penetrations Through or Under Levee	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Slope stability • Internal erosion • Lack of information regarding existing penetrations • Inability to remediate past seepage distress • Inability to properly remediate seepage • Longevity of penetration materials • Inadequate closure devices • Hidden deficiencies
2. Policy	<ul style="list-style-type: none"> • Inconsistency among and between local, State, and Federal agencies regarding penetration policy • Regulatory constraints to waterside improvements and repairs • Difficulty of enforcing encroachment policies • Existence of penetrations impedes levee repairs and improvements (<i>also Technical Risk Factor</i>) • Inconsistent welding standards for steel pipes • Title 23 needs to be updated
3. Financial Constraints	<ul style="list-style-type: none"> • High cost to bring existing penetrations to new standards • High cost to analyze, modify, or remove penetrations • High cost and duration of litigation
Levee Settlement: Upper San Joaquin Specific Groundwater and Oil Extraction	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Under seepage • Slope stability • Overtopping
2. Policy	<ul style="list-style-type: none"> • Lack of groundwater regulation • Lack of surface water availability • Environmental constraints • Lack of regulation for oil extraction impacts (?) • Unclear agency responsibility for repairing deficient levee geometry (not maintenance issue or original design flaw)
3. Financial Constraints	<ul style="list-style-type: none"> • Limited Federal/State/local funding • Lack of identified funding mechanism

**3.0 Primary Categories of Existing Problems and Expected
Future Challenges Within the CVFPP Planning
Area Related to Levee Performance**

**Table 3-1. Existing Problems and Expected Future Challenges by
Category (Contd.)**

Problems and Challenges Related to Important Key Factors, Contd.	
Substandard Levee Modifications and Repairs	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Slope stability • Seepage through the levee • Seepage through the foundation • Settlement • Wave and wake erosion • Loss of critical section
2. Policy	<ul style="list-style-type: none"> • Lack of oversight • Time required for environmental permitting • Lack of policy to prevent temporary repairs from becoming permanent repairs
3. Financial Constraints	<ul style="list-style-type: none"> • Inadequate resources of local levee maintaining agencies • Liability for regulatory penalties • Cost of environmental mitigation • Loss of Federal funding for flood repair • Cost of removal of past temporary repairs and replacement with permanent repairs • Liability for inadequate modifications and repairs resulting in failure
Rainfall Duration and Intensity	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Slope stability • Weathering effects • Saturation of levee slope and foundation • External erosion of the levee slope • Naturally occurring artesian conditions • Improper internal drainage control • Impacts to flood fighting, maintenance, repairs, and inspection
2. Policy	<ul style="list-style-type: none"> • Title 23 • Access requirements for maintenance, repairs, inspections, and emergency response and emergency action plans • Private property constraints • Interior drainage requirements, including development and hardscaping
3. Financial Constraints	<ul style="list-style-type: none"> • None identified

Table 3-1. Existing Problems and Expected Future Challenges by Category (Contd.)

Problems and Challenges Related to Less Important Key Factors, Contd.	
Vegetation Roots and Treefall	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Killing trees on the landside due to too much water • Sudden large-scale mortality of woody vegetation – slope stability • Waterside treefall – large individual tree at top of levee, leading to overtopping/failure • Horizontal versus vertical roots – one may be harmful and one may be beneficial • Lack of inspection access for flood fighting • Difficulty identifying seepage impacts associated with tree roots • The windfalls are important inputs to fish habitat (i.e., Instream Woody Material) • Erosion • Inability to inspect or repair
2. Policy	<ul style="list-style-type: none"> • Title 23 • Compensate/mitigate for impacts to flood conveyance, jeopardy opinion on waterside • Environmental regulations (e.g., USACE) • USACE policy; lack of maintenance • Lack of policy enforcement
3. Financial Constraints	<ul style="list-style-type: none"> • Cost of remediating levee system if roots need to be removed • Cost of mitigation and natural habitat restoration • Cost of erosion repair • Cost of seepage mitigation
Construction and Manmade Activities	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Construction traffic and loading • Temporary levee degradation • Erosion control • Cofferdams and other temporary barriers • Post-construction stability • Changed conditions resulting in design changes • Hydrologic risk of high water • Wave wash protection • Loss of vegetation and habitat • Working hours in urban areas
2. Policy	<ul style="list-style-type: none"> • Criteria for post-construction stability • Environmental constraints • Variable regulatory requirements
3. Financial Constraints	<ul style="list-style-type: none"> • Cost of environmental mitigation • Construction materials availability • Local funding availability

**3.0 Primary Categories of Existing Problems and Expected
Future Challenges Within the CVFPP Planning
Area Related to Levee Performance**

**Table 3-1. Existing Problems and Expected Future Challenges by
Category (Contd.)**

Problems and Challenges Related to Less Important Key Factors, Contd.	
Closure Structures and Embankments	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Stability and seepage • Underseepage • Variable design considerations • Erosion around or beneath existing or new closure structures • Operation responsibility • Impacts to adjacent properties
2. Policy	<ul style="list-style-type: none"> • Inconsistent minimum State or Federal Standards • Environmental constraints
3. Financial Constraints	<ul style="list-style-type: none"> • High cost to bring existing closure structures and embankments to new standards • High initial cost for new structures • Construction materials availability • Environmental mitigation costs
Earthquakes	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Liquefaction • Slope stability • Inability to access for flood fighting • Potential for internal erosion • Potential for external erosion • Through seepage • Structural failures • Settlement • Cracking • Quick repair needs, prior to flood season
2. Policy	<ul style="list-style-type: none"> • Lack of clear seismic design criteria • Do not design for earthquakes as cost is prohibitive and earthquakes are rare events and levees unlikely to be holding water at the time of earthquake • Need to develop an emergency action plan to manage seismic risk, including estimate of potential damage, identification of borrow areas and haul routes in advance, development of plan assuming USACE in lead of quick interim repair and State to provide lands, easements, borrow, and right of way with updates every few years.
3. Financial Constraints	<ul style="list-style-type: none"> • High cost to analyze levees for stability • Funding necessary to assess seismic vulnerability • Funding necessary to develop emergency action plan • Assumes Federal emergency funding available for interim emergency repair

Table 3-1. Existing Problems and Expected Future Challenges by Category (Contd.)

Problems and Challenges Related to Less Important Key Factors, Contd.	
Delta Island Subsidence: Organic Soil Decomposition	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Slope stability
2. Policy	<ul style="list-style-type: none"> • Variable safety factors • Changing engineering standards • New government priorities • New legislation
3. Financial Constraints	<ul style="list-style-type: none"> • Limited funding abilities • Availability and cost of material delivery and placement
Levee Settlement	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Under seepage • Slope stability • Overtopping • Landside erosion from overtopping • Loss of critical section • Lack of technical information regarding existing structures
2. Policy	<ul style="list-style-type: none"> • Lack of groundwater regulation • Lack of surface water availability • Environmental constraints • Lack of regulation for oil extraction impacts (?) • Unclear agency responsibility for repairing deficient levee geometry (not maintenance issue or original design flaw) • Variable safety factors and design flood elevations • Changing engineering standards • New regulations • New legislation • New government priorities
3. Financial Constraints	<ul style="list-style-type: none"> • Limited Federal/State/local funding • Lack of identified funding mechanism • High cost of mitigation for repairs • USACE benefit/cost ratio • High construction costs

**3.0 Primary Categories of Existing Problems and Expected
Future Challenges Within the CVFPP Planning
Area Related to Levee Performance**

**Table 3-1. Existing Problems and Expected Future Challenges by
Category (Contd.)**

Problems and Challenges Related to Less Important Key Factors, Contd.	
Levee Settlement: Delta Specific Consolidation of Organic Foundation Materials	Existing Problems and Future Challenges
1. Technical Risk Factor	<ul style="list-style-type: none"> • Loss of freeboard or overtopping • Potential for slope instability as material is added to maintain freeboard • Potential for cracking/piping due to differential settlement, particularly as material is added to restore freeboard • Potential for inadequate levee width following settlement
2. Policy	<ul style="list-style-type: none"> • Eligibility for HMP • Eligibility for PL 84-99 • Unclear responsibilities • Environmental regulatory policies
3. Financial Constraints	<ul style="list-style-type: none"> • Lack of funding for levee freeboard/cross section restoration • Benefit/cost ratios • Cost of ground stabilization • Cost of levee rehabilitation • Limited Federal/State funding

Key:
 DRMS = Delta Risk Management Strategy
 HMP = Hazard Mitigation Plan
 PL = Public Law
 USACE = U.S. Army Corps of Engineers

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4.0 Reference Material Related to Levee Performance Problems, Opportunities, and Standards

For Deliverable #3, LPSDWG partners reviewed and updated a list of previously provided material to create a list of most applicable documents to use as reference material related to levee performance problems, opportunities, and standards. A large volume of reference material has been collected by the DWR Levee Evaluations Programs (approximately 8,000 documents). Considering this database, the LPSDWG partners developed a shortlist of documents determined to be most applicable to development of the CVFPP, and frequently used in the LPSDWG partners' respective fields related to levee performance.

The list includes 57 reference documents pertaining to levee performance problems, opportunities, and standards, as listed below:

1. California Department of Water Resources, 2008. "Delta Risk Management Strategy Phase 1, Final Risk Analysis Report," December.
2. California Department of Water Resources, 2009. "Draft Guidance Document for Geotechnical Analyses, Urban Levee Geotechnical Evaluation Program, Revision 7," February.
3. California Department of Water Resources, 2005. "Flood Warnings: Responding to California's Flood Crisis," January.
4. California Department of Water Resources, 1998. "Memorandum Report After-Action Report February 1998 Floods," July.
5. California Department of Water Resources, 2009. "Third Draft Interim Levee Design Criteria for Urban and Urbanizing Area State-Federal Project Levees," May 15.
6. California Levee Roundtable, 2009. "California's Central Valley Flood System Improvement Framework," March.
7. National Committee on Levee Safety, 2009. "Draft: Recommendations For a National Levee Safety Program, A Report to Congress from the National Committee on Levee Safety," January 15.

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8. State of California Code of Regulations, 1990. "Title 23. Waters" April 1 (the most updated will be included, August 2009).
9. State of California, Governor's Delta Vision Blue Ribbon Task Force, 2008. "Delta Vision Strategic Plan," October.
10. State of California, Governor's Delta Vision Blue Ribbon Task Force, 2008. "Our Vision for the California Delta," January 29.
11. State of California, Sixth District Court of Appeal, 2002. "JAMES ARREOLA et al., Plaintiffs and Respondents, v. COUNTY OF MONTEREY et al., Defendants and Appellants, No. H021339," June 25.
12. State of California, Third District Court of Appeal, 2003. "Peter PATERNO et al., Plaintiffs and Appellants, v. STATE of California et al., Defendants and Respondents No. C040553," November 26.
13. U.S. Army Corps of Engineers, 2009. ETL 110-2-571, "Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures," April.
14. U.S. Army Corps of Engineers Sacramento District, 2002. "Sacramento and San Joaquin River Basins California Comprehensive Study Interim Report," December 20.
15. U.S. Army Corps of Engineers Sacramento District, 2002. "Sacramento and San Joaquin River Basins California Comprehensive Study Technical Studies Documentation," December.
16. U.S. Army Corps of Engineers, 1996. EM1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies," August 1.
17. U.S. Army Corps of Engineers, 2001. EM 1110-1-1804, "Engineering and Design - Geotechnical Investigations," January.
18. U.S. Army Corps of Engineers, 1990. EM 1110-1-1904, "Engineering and Design - Settlement Analysis," September.
19. U.S. Army Corps of Engineers, 2003. EM 1110-2-1902, "Engineering and Design - Slope Stability," October.
20. U.S. Army Corps of Engineers, 2000. "EM1110-2-1913, Design & Construction of Levees," April 30.

4.0 Reference Material Related to Levee Performance Problems, Opportunities, and Standards

21. U.S. Army Corps of Engineers, 1992. "EM1110-2-1914, Design, Construction and Maintenance of Relief Wells," May 29.
22. U.S. Army Corps of Engineers, 2000. "EM1110-2-301, Guidelines for Landscape Planting on Floodwalls, Levees & Embankment Dams," January 1.
23. U.S. Army Corps of Engineers, 1989. EM 1110-2-2502, "Engineering and Design - Retaining and Flood Walls," September.
24. U.S. Army Corps of Engineers, 2005. "ETL 1110-2-569, Engineering and Design, Guidance for Levee Underseepage," May 1.
25. U.S. Army Corps of Engineers, 2009. "ETL 1110-2-570 (Draft) Certification of Levee Systems for the National Flood Insurance Program," April 10.
26. U.S. Army Corps of Engineers, 2006. ETL 1110-2-561 "Reliability Analysis and Risk Assessment for Seepage and Slope Stability Failure Modes for Embankment Dams," January.
27. U.S. Army Corps of Engineers, 2009. ETL 1110-2-571 "Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures," April.
28. U.S. Army Corps of Engineers, 2009. "Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System Final Report of the Interagency Performance Evaluation Task Force," June.
29. U.S. Army Corps of Engineers, Engineer Research and Development Center, 2001. "ERDC TR-01-16, Environmental Considerations for Vegetation in Flood Control Channels," J. Craig Fischenich, Ronald R. Copeland, December.
30. U.S. Department of Homeland Security - Federal Emergency Management Agency, 2005. "Procedure Memorandum 34 - Interim Guidance for Studies Including Levees," August 22.
31. U.S. Department of Homeland Security - Federal Emergency Management Agency, 2007. "Revised Procedure Memorandum 43 - Guidelines for Identifying Provisionally Accredited Levees," March 16.

32. U.S. Department of Homeland Security - Federal Emergency Management Agency, Title 44 CFR Section 65.10 Nation Flood Insurance Program, 2000. "Mapping of Areas Protected by Levees," October 1.
33. United States Army Corps of Engineers, Sacramento District, 1999. "Sacramento and San Joaquin River Basins, California, Post-Flood Assessment," March.
34. Resources Agency of California, 1997. "Final Report – Governor’s Flood Emergency Action Team," May 10.
35. Galloway G., Boland, J. Burby, R. J., Groves, C. B., Longville S., Link, L. E., Mount, J. F., Opperman, J., Seed, R.B., Sills, G. L., Smyth, J. J., Stork, R., Thomas, E., 2007. "A California Challenge--Flooding in the Central Valley," A Report to the Department of Water Resources, State of California, October 15.
36. Seed, R., Bea, R., Abdelmalak, R., Athanasopoulos, A., Boutwell, G., Bray, J., Briaud, J.-L., Cheung, C., Cohen-Waeber, J., Collins, B., Cobos-Roa, D., Farber, D., Hanenmann, M., Harder, L., Inkabi, K., Kammerer, A., Karadeniz, D., Kayen, R., Moss, R., Nicks, J., Nimala, S., Pestana, J., Porter, J., Rhee, K., Riemer, M., Roberts, K., Rogers, J., Storesund, Govindasamy, A., Vera-Grunauer, X., Wartman, J., Watkins, C., Wenk, E., Yim, S., 2006 "Investigation of the Performance of the New Orleans Flood Protection Systems in Hurricane Katrina on August 29, 2005, Volume I: Main Text and Executive Summary, Final Report July 31, 2006," Independent Levee Investigation Team, Center for Information Technology Research in the Interests of Society (CITRIS), University of California, Berkeley.
37. California Department of Water Resources, 2008. "DRAFT FloodSAFE Strategic Plan," December.
38. State of California, 2006. "The Disaster Preparedness and Flood Protection Bond Act of 2006 (Proposition 1E)."
39. State of California, 2006. "The Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006 (Proposition 84)."
40. State of California, 2007. "Senate Bill 5/Assembly Bill 5 (Machado/Wolk)."

4.0 Reference Material Related to Levee Performance Problems, Opportunities, and Standards

41. Leslie F. Harder, Jr. etc, "Improving Flood Protection Understanding How levees are Different From Dams," (2009).
42. U.S. Army Corps of Engineers, 2009. "Final Report: The Spring 2008 Midwest Flood."
43. George L. Sills and Leslie F. Harder, Jr., "Flood Fighting for Levees and Failures," 2009.
44. "Assembly Bill 156," 2008.
45. DWR, 2008. AB 156, Local Agency Annual Report 2008 for Project Levees of the State Plan of Flood Control.
46. Flood Emergency Action Team (FEAT), 1997. Final Report of the Flood Emergency Action Team – 1997.
47. Mussetter Engineering, Inc. and Jones & Stokes Associates, Inc., 2000. Evaluation of Roughness Effects of Increased Vegetation Associated with 1999 Pilot Project Flow Releases, prepared for the Friant Water Users Authority and the Natural Resources Defense Council, May.
48. U.S. Department of the Interior, Bureau of Reclamation, 2008. San Joaquin River Restoration Program (SJRRP) Team. Preliminary Draft Initial Program Alternatives Report, June. (Preliminary draft document, subject to revision as the SJRRP proceeds)
49. DWR, 1995. Sacramento-San Joaquin Delta Atlas. July.
50. National Marine Fisheries Service, 2009. "Public Draft Central Valley Salmon and Steelhead Recovery Plan."
51. Basham, Donald L., Harder, Leslie F., Verigin, Steve W., and Williams, Warren D., 2009. "Engineering Perspectives for a National Levee Safety Program."
52. Groves, Chris, Harder, Les, Kelley, Julie R., Sills, George, and Vroman, Noah, 2009. "The Spring 2008 Midwest Flood, Observations of Missouri and Iowa Levee Breaches, 21-23 July 2008."
53. Groves, Chris, Harder, Les, Kelley, Julie R., Sills, George, and Vroman, Noah, 2009. "Inspection of Levee Distress and Breaches During the Spring 2008 Midwest Flood."

54. Northwest Hydraulic Consultants, 2000. "Final Work Products for Paradise Cut 1997 Flood Case".
55. Amendment #5 to the FEMA-State Agreement for FEMA-758-DR.
56. USACE, 1992. Sacramento River Flood Control System Evaluation Phase IV.
57. Sacramento River Corridor Forum, 2007. Sacramento River Corridor Planning Forum Floodway Management Plan.

5.0 Relevant Levee Performance Evaluation Activities to be Considered in the 2012 Plan

The LPSDWG partners reviewed and updated a list of previously compiled levee performance evaluation activities to develop a comprehensive list of other levee performance evaluation activities that the CVFPP Plan Development Team should become familiar with and coordinate with regularly. The activities were divided into ongoing and complete activities within three categories (DWR, USACE, and Regional/Local). The list is provided below.

5.1 Department of Water Resources Activities

5.1.1 Ongoing Department of Water Resources Activities

- Urban Levee Geotechnical Evaluation Program
- Non-urban Geotechnical Levee Evaluation Program
- USACE/ SAFCA/DWR Levee Vegetation Research Collaborative Construction inspections
- Central Valley Flood Protection Board inspections, reviews, permitting activities
- Assembly Bill (AB) 156 Levee Conditions Survey
- Levee Maintenance Authority(ies) Inspection Reports (DWR; Levee Districts (LD); RDs,)
- Urban Levee Geotechnical Evaluations – Geotechnical Data Reports (varies, 2008/09), as part of DWR Urban Levee Evaluations
- San Joaquin River Restoration Program
- Senate Bill (SB) 5: Requirements for Lower San Joaquin River Bypass Analysis
- Early Implementation Program (EIP) Guidelines

- California Levee Vegetation Research Program
- Central Valley Floodplain Evaluation and Delineation
- Building Standard Code Update Project
- Title 23 Revisions
- Interim Levee Repairs Framework
- Bay Delta Conservation Plan
- Delta Levee Subventions and Special Projects Program
- DWR/SAFCA Natomas Levee Improvement Program
- DWR/West Sacramento Area Flood Control Agency (WSAFCA) West Sacramento Levee EIP
- DWR Interim Levee Design Guidance

5.1.2 Completed Department of Water Resources Activities

- FloodSAFE Strategic Plan – Public Review Draft (June 2008)
- Sacramento and San Joaquin River Basins California, Comprehensive Study – Interim Report (December 2002)
- California Flood Management Task Force, Management Report (December 2002)
- Delta Risk Management Strategy – Phase I Report (February 2009)
- Sacramento and San Joaquin River Basins, California, Post-Flood Assessment (March 1999)
- Final Report – Governor’s Flood Emergency Action Team (May 1997)
- San Joaquin River System Levee Repair Prioritization Report (December 2007)
- Flood Warnings: Responding to California’s Flood Crisis (2005 White Paper; January 2005)

- California Levee Roundtable - California's Central Valley Flood Control Improvement Framework (February 2009)
- Third Draft Interim Levee Design Criteria for Urban and Urbanizing Area State-Federal Project Levees
- Levee Flood Protection Zone maps (2008)

5.2 U.S. Army Corps of Engineers Activities

5.2.1 Ongoing U.S. Army Corps of Engineers Activities

- Annual Project levee inspections
- Periodic Levee Inspection and Assessment
- System Analysis of State Plan of Flood Control
- Sacramento River Bank Protection Program, California (Flood control system maintenance repairs construction authority)
- CALFED Delta Levee Stability Program
- Water Resources Development Act (WRDA) CALFED 2007 - Sacramento San Joaquin Delta – Delta Islands and Levees Feasibility Study
- Sutter and Butte County Feasibility Study (with Sutter-Butte Flood Control Agency and DWR)
- American River Common Features General Reevaluation Report (GRR)
- Sacramento River Bank Protection Program (Future maintenance authority projects)
- West Sacramento General Reevaluation Report (Feasibility study; starting 2009)
- Lower San Joaquin River Feasibility Study (with SJAFCA)
- WRDA 2007 Periodic Inspections
- Levee Assessment Pilot Study

- Natomas Post-Authorization Change Report
- Natomas GRR
- Integrated Flood Management Study
- Natomas Levee Improvement Program (NLIP) Phase 4B
- Marysville Project Engineering Design Documentation
- WRDA 96/99 Sacramento and American River Improvement Program

5.2.2 Completed U.S. Army Corps of Engineers Activities

- Lower Cache Creek Feasibility Study (March 2003)
- Yuba River Basin Project, California (Feasibility Study, April 1998)
- Sacramento River Flood Control Project, California, Mid-Valley Area, Phase III (August 2005)
- San Joaquin River Restoration Program – Initial Program Alternatives Report (June 2008)
- Public Law (PL) 84-99 for 2006 High Water Event
- Mayhew Levee Improvement Project

5.3 Regional or Local Activities

5.3.1 Ongoing Regional or Local Activities

- NLIP
- Cache Creek Comprehensive Flood Management Program (as sponsored by Yolo County, not USACE)
- West Sacramento EIP
- Sutter Butte Flood Control Agency Early Implementation Program
- RD 17 Improvements/Repairs
- TRLIA Levee Improvements on Feather River, Bear River, Yuba River, Western Pacific Interceptor Canal (WPIC)

5.0 Relevant Levee Performance Evaluation Activities to be Considered in the 2012 Plan

- Various Levee Improvement Projects (SJAFCA)
- Hamilton City Flood Control and Environmental Restoration Project
- RD 404 Improvement/Repairs
- Development Fee Program, Erosion Studies, etc.

5.3.2 Completed Regional or Local Activities

- Lower Cache Creek Bank Protection (recent projects by DWR)

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6.0 Acronyms and Abbreviations

AB	Assembly Bill
Board	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
DRMS	Delta Risk Management Strategy
DWR	California Department of Water Resources
EIP	Early Implementation Program
EJ.....	environmental justice
GRR.....	General Re-evaluation Report
HMP	Hazard Mitigation Plan
LD	Levee District
LPSDWG.....	Levee Performance Scope Definition Work Group
NLIP	Natomas Levee Improvement Program
PL.....	Public Law
RCSR.....	Regional Conditions Summary Report
RD.....	Reclamation District
SAFCA	Sacramento Area Flood Control Agency
SB	Senate Bill
SJAFCA	San Joaquin Area Flood Control Agency
TRLIA.....	Three Rivers Levee Improvement Authority
USACE.....	U.S. Army Corps of Engineers
WPIC.....	Western Pacific Interceptor Canal
WRDA	Water Resources Development Act
WSAFCA.....	West Sacramento Area Flood Control Agency

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